Persistence of Grazing Tolerant Lucernes under Australian Conditions

J.C. SEWELL[1], R.D. HILL[1], and J.REICH[2]
[1]*PGGWrightson Seeds, Ballarat Research Farm, Australia*
[2]*Cal/West Seeds, California, USA*
jsewell@pggwsa.com.au

Abstract
Recent experiments have demonstrated that lucerne (*Medicago sativa)* varieties selected for grazing tolerance will persist far better when grazed for extended periods than varieties not selected for grazing tolerance. A field experiment, with lucerne varieties representing a range of winter activity ratings, was conducted at Ballarat. After 2.5 years of rotational grazing the experiment was continuously grazed for 173 days from late spring to early autumn at a stocking rate equivalent to 50 sheep/ha. This intensity is not considered much higher than some farmers would adopt during a drought. Ground cover of some varieties had significantly declined by the end of the grazing period but further decline occurred throughout the following winter months while livestock were excluded. The grazing tolerant lines persisted better than most standards, even those within the same dormancy category, with some standards almost completely dead while the grazing tolerant lines were over 60% alive.
Keywords: grazing tolerance, lucerne (*Medicago sativa*), persistence

Introduction
Lucerne (*Medicago sativa*) is the most widely grown perennial pasture legume in Australia (Lodge 1991). It will persist if strict management practices are adhered to and it is well understood that, for long-term productivity, lucerne pastures require rotational grazing (Leach 1968). Numerous studies recommend a minimum spell period of around 35 days and a short grazing period (Lodge 1991). These practices should provide a reasonable balance between persistence, quality, yield and animal safety. Nevertheless, many Australian farmers find ideal grazing management techniques impracticable and hard to sustain under tough seasonal conditions.

There are a number of factors which contribute to the low rate of adoption of ideal grazing rotations. Paddocks are often too large and high costs are associated with sub-dividing and watering in broadacre pasture systems, additional management is required and perhaps there is a poor understanding of the benefits of rotational grazing. However, the greatest obstacle to adoption is that over a long dry summer, when the only green feed on the farm is lucerne, farmers will leave their valuable stock on lucerne for extended periods despite the, known, consequences.

The adverse effects of continuous grazing on lucerne plants have been reported by Smith *et al.* (1989) and set-stocking with high stocking rates under dry Australian conditions will most likely result in a rapid decline in stand persistence (Brownlee 1973). There is a strong correlation between winter dormancy and grazing tolerance (Humphries *et al.* 2006; Bouton & Gates 2003), but there are also a number of other traits that contribute to differences in lucerne persistence under grazing. Smith *et al.* (1989) and Humphries *et al.* (2006) cite various authors who have found that grazing tolerance in lucerne has been linked to deep set crowns, decumbency or prostrate habit, subsurface budding, broad crowns, prolific and non-synchronous budding, extended periods of budding, maintenance of leaf area under grazing and maintenance of root carbohydrates.

A 6-year grazing tolerance screening programme, which was conducted in the United States by Cal/West Seeds, combined elite breeding lines and successful commercial cultivars. Experiments were continuously grazed by both sheep and beef cattle for lengthy periods at high stocking rates, following the protocol developed at the University of Georgia and the North American Alfalfa Improvement Conference (NAAIC) standard test protocol (Bouton & Smith 1998). Further screening of 24 lines of elite material from this programme, and 14 commercially available cultivars, was conducted at two sites in Australia by Wrightson Seeds from 1999 to 2005 (Salmon & Hill 2008). After 4 years of rotational grazing, the Ballarat (south western Victoria) experiment was subjected to continuous grazing for 2 years (40 sheep/ha with a 2-month spell after 10 months). A similar experiment was conducted at Gundagai (southern New South Wales) where a severe drought was experienced; final selections were made from plants subjected to this extreme stress. Almost all of the US lines developed for grazing tolerance persisted better than the 'Australian' commercial cultivars. Two test lines were identified as having an ideal balance of persistence, winter activity and yield

Table 1 Ground cover percentages per metre row for the pre-grazing, first assessment (7th April 2010) and final assessment (8th September 2010) and cumulative yield (DM t/ha) before continuous grazing.

Cultivar	Winter Activity	Cumulative DM t/ha until 2/02/2009†		Ground Cover % Initial 18/12/2006	First† 7/4/2010		Final† 8/9/2010	
Non-grazing tolerant varieties								
Aurora	6	19.52	defg	94	51	gh	23	fghij
Australis	9	21.85	abc	97	29	i	5	k
Genesis	7	18.36	g	92	66	ef	28	fghi
Hunterfield	6	18.68	fg	95	70	e	47	de
Icon	6	21.40	abcd	93	38	hi	14	ijk
Kaituna	5	22.33	a	92	76	cde	36	ef
PGWS-4	6	20.42	abcdefg	94	47	gh	18	hijk
PGWS-6	7	22.25	ab	94	78	bcde	35	efg
PGWS-7	7	20.04	bcdefg	94	55	fg	25	fghi
Sardi 7	7	19.07	efg	93	43	ghi	20	ghij
SD 54Q53	4	20.61	abcdef	92	69	ef	35	efg
SD L56	5	21.54	abcd	93	72	de	32	efgh
UQL-1	7	21.21	abcde	95	38	hi	10	jk
Mean		20.56		94	56		25	
Grazing tolerant varieties								
PGWS-1	5	20.96	abcde	93	87	abc	67	c
PGWS-2	4	20.75	abcdef	89	89	abc	71	bc
PGWS-3	6	20.25	abcdefg	96	77	cde	68	bc
PGWS-5	3	19.75	cedefg	94	93	a	82	ab
Stamina 5	5	19.95	cdefg	96	92	ab	90	a
Stamina GT6	6	20.83	abcdef	97	85	abcd	61	cd
Venus	5	20.55	abcdefg	89	91	ab	76	abc
Mean		20.43		93	88		74	
LSD (0.05)		2.25		4.5	14.4		15.5	
CV%		7.8		3.4	15.1		25.9	

†Means with the same letters within a column are not significantly different (P<0.05)

and released as 'Stamina 5' and 'Stamina GT6'.

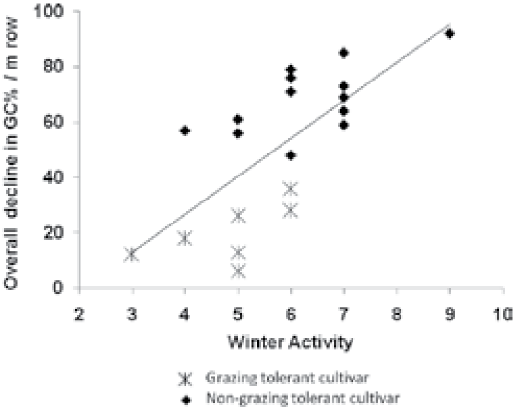
Here we report a subsequent experiment established in 2006 at the PGGWrightson Seeds Ballarat Research Farm to evaluate new experimental grazing-tolerant lines, including selections taken from the 1999-sown experiments (above) and commercial cultivars.

Methods

Experimental treatments and design

The NAAIC standard test protocol to screen lucerne for grazing tolerance (Bouton & Smith 1998) was used, however there was one major exception being that sheep were used in this experiment, rather than cattle, for closer grazing.

Figure 2 Relationship between winter activity rating and overall decline in stand density (GC%). R2 = 0.499.



The trial was drill-sown on the 1st of September 2006 at the PGGWrightson Seeds Research Farm at Ballarat (37°56'S, 143°95'E), south-western Victoria. The soil is a deep red Krasnozem derived from volcanic ash. The site was previously limed, sprayed with 3 lt/ha of Roundup 1 month prior to cultivation, and the seedbed was prepared to a fine tilth.

There were 20 entries comprising 13 commercially available cultivars representing various winter activity ratings, including 'Stamina 5' and 'Stamina GT6' as the grazing tolerant control types, and seven experimental lines of varying winter-activity ratings labelled PGWS-1 to PGWS-7. PGWS-1,2,3 and 5 were specifically developed for grazing tolerance. The seeding rate was 20 kg/ha and all seed was lime coated and inoculated, and sown with a 10-row, precision cone-seeder and roller.

Plots of 1.30 x 5.08 m were laid out as a randomly allocated factorial design with four replicates. The plot area was surrounded by a 10-m border sown to lucerne. Drinking water, a supplement feeding area and a shade house were situated along the fence-lines and 10 m away from the trial plots.

Grazing

After reaching an initial flowering stage, the experiment was rotationally grazed/cut for 2.5 years and yields were recorded. After the 3rd October 2009 the trial was continuously grazed with 14 crossbred wethers (equivalent to 50 sheep/ha) until the 25th March 2010 (173 days). The sheep were fed a supplement of grain towards the end of the grazing period. After an assessment of ground cover was made, the lucerne was chemically 'winter cleaned' (2.5 lt/ha diuron; 2 lt/ha diquat) and plants allowed to recover to ensure no depletion of the stand occurred due to chemical application. The experimental plots were then spelled until September when, after 3 days of grazing, a further assessment was made.

Measurements and Analysis

Ground cover was measured on the 18th December 2006. Subsequent measurements were made 13 and 7 days, respectively, after de-stocking in April and September 2010. These intervals allowed the lucerne to regrow to 5 – 7.5 cm height. The proportion of a 1.0 m length of drill row supporting lucerne growth was visually assessed from six randomly selected sites within each plot to provide an estimate of ground cover. Analysis of variance was carried out using the 'Statistix 2.0' program.

Results and Discussion

Differences in persistence between the grazing tolerant and the non-grazing types had become visually apparent during the first grazing period and were reflected in the April 2010 assessment (Table 1). Stand density was significantly reduced in the non-grazing tolerant types after this initial 5 months of set-stocking. Despite minimal grazing over the winter the non-grazing tolerant types continued to decline, presumably due to their depleted energy reserves, and the September assessment revealed significantly less ground cover than the April assessment.

Defoliation in autumn can reduce the level of root carbohydrate reserves in the plant, the level of winter hardiness and survival and the number of crown buds available for spring growth (Smith 1972). Winter injury from extreme cold is unlikely to occur in Australia, although autumn and winter grazing may affect long-term persistence (Lodge 1991), particularly for non-grazing tolerant types. Brummer & Bouton (1992) suggested that the ability of cultivars to produce and store high levels of total non-structural carbohydrates may enhance grazing tolerance. This physiological attribute is particularly important through the critical autumn period under continuous grazing.

Stamina 5 was the most persistent cultivar with a 6% decline in stand density over 4 years. Some of the experimental lines selected under continuous grazing persisted well (e.g., PGWS-5, 3 and 2) but none were superior to Stamina 5. Almost all of the lines developed for grazing tolerance persisted significantly better than the non-grazing tolerant types, irrespective of dormancy group. The only exception to this was Hunterfield (47% final ground cover). All the grazing tolerant lucernes had final ground covers greater than 60%.

These results show that selection of diverse winter activity groups for grazing tolerance can be effective in lucerne. Considerable differences in persistence occurred between varieties within the same winter activity group – Stamina GT6 (61%) versus Icon (14%)

both winter active 6, and Stamina 5 (90%) versus SDL56 (32%) both winter active 5. The negative correlation between higher winter activity and grazing tolerance (Fig. 1) supports previous findings (Brummer & Bouton 1991; Smith *et al.* 1989). Similar results under grazing by sheep in Australia have also been recorded by Humphries *et al.* (2006) who reported final plant frequencies ranging from 0 -13 % for highly winter-active entries and 11-40% for winter dormant entries.

Improved persistence also results in reduced weed invasion (Bouton *et al.* 2001) and grazing tolerant lines have been shown to yield as well, or better, than non-grazing tolerant lines even under rotational stocking and mechanical hay harvesting (Bouton & Gates 2003). Cumulative dry matter yield for the 2.5 years before the continuous grazing treatment (Table 1) indicates that there was very little difference in overall yield for the grazing tolerant and non-grazing tolerant varieties. However, the grazing tolerant varieties are likely to produce superior yields after the grazing stress due to higher plant density (Bouton *et al.* 2001).

Most Australian farmers understand the need for appropriate spells to enable lucerne to replenish carbohydrate reserves. In times of drought, however, lucerne will be overgrazed and the benefits of grazing tolerant lucernes such as Stamina 5 and Stamina GT6 should be significant.

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